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 Direct Replacements for PMI and LTC OP27 and OP37 Series

Features of OP27A, OP27C, OP37A, and OP37C:

- Maximum Equivalent Input Noise Voltage: 3.8 nV/√Hz at 1 kHz 5.5 nV/√Hz at 10 kHz
- Very Low Peak-to-Peak Noise Voltage at 0.1 Hz to 10 Hz ... 80 nV Typ
- Low Input Offset Voltage . . . 25 μV Max
- High Voltage Amplification ...1 V/μV Min

#### Feature of OP37 Series:

• Minimum Slew Rate ...11 V/μs

#### description

The OP27 and OP37 operational amplifiers combine outstanding noise performance with excellent precision and high-speed specifications. The wideband noise is only  $3 \text{ nV/}\sqrt{\text{Hz}}$  and with the 1/f noise corner at 2.7 Hz, low noise is maintained for all low-frequency applications.

The outstanding characteristics of the OP27 and OP37 make these devices excellent choices for low-noise amplifier applications requiring precision performance and reliability. Additionally, the OP37 is free of latch-up in high-gain, large-capacitive-feedback configurations.

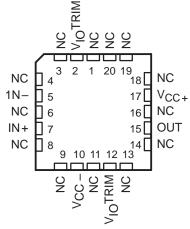
The OP27 series is compensated for unity gain. The OP37 series is decompensated for increased bandwidth and slew rate and is stable down to a gain of 5.

The OP27A, OP27C, OP37A, and OP37C are characterized for operation over the full military temperature range of -55°C to 125°C. The OP27E, OP27G, OP37E, and OP37G are characterized for operation from - 25°C to 85°C.

# V<sub>IO</sub> TRIM 1 8 V<sub>IO</sub> TRIM 1 V<sub>CC+</sub> 1 V<sub>CC+</sub> 3 6 OUT V<sub>CC-</sub> 4 5 NC

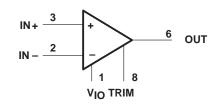
JG OR P PACKAGE

FK PACKAGE (TOP VIEW)



NC - No internal connection

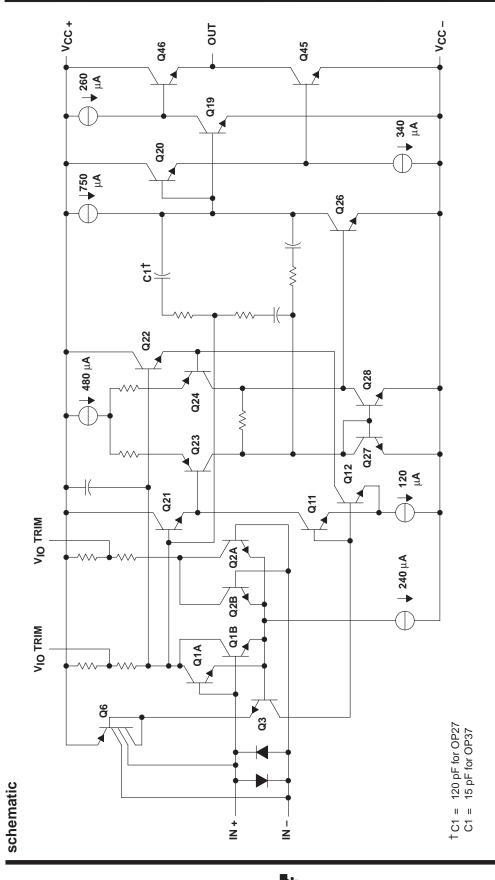
#### symbol



Pin numbers are for the JG and P packages.

#### **AVAILABLE OPTIONS**

	V <sub>IO</sub> max	STABLE	PACKAGE					
TA	AT 25°C	GAIN	CERAMIC DIP (JG)	CHIP CARRIER (FK)	PLASTIC DIP (P)			
	25\/	1	_	_	OP27EP			
-25°C to 85°C	25 μV	5	_	_	OP37EP			
-25 C to 65 C	100 μV	1	_	_	OP27GP			
	100 μν	5	_	_	OP37GP			
	25 μV	1	OP27AJG	OP27AFK	_			
-55°C to 125°C	25 μν	5	OP37AJG	OP37AFK	_			
-55 0 10 125 0	100 μV	1	OP27CJG	_	_			
	100 μν	5	OP37CJG	_	_			



#### OP27A, OP27C, OP27E, OP27G OP37A, OP37C, OP37E, OP37G

#### LOW-NOISE HIGH-SPEED PRECISION OPERATIONAL AMPLIFIERS

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#### absolute maximum ratings over operating free-air temperature range (unless otherwise noted)

Supply voltage, V <sub>CC+</sub> (see Note 1)
Supply voltage, V <sub>CC</sub> (see Note 1) – 22 V
Input voltage, V <sub>I</sub> V <sub>CC±</sub>
Duration of output short circuit unlimited
Differential input current (see Note 2) ±25 mA
Continuous power dissipation
Operating free-air temperature range: OP27A, OP27C, OP37A, OP37C – 55°C to 125°C
OP27E, OP27G, OP37E, OP37G – 25°C to 85°C
Storage temperature range – 65°C to 150°C
Lead temperature 1,6 mm (1/16 inch) from case for 60 seconds: JG or FK package
Lead temperature 1,6 mm (1/16 inch) from case for 10 seconds : P package

NOTES: 1. All voltage values are with respect to the midpoint between V<sub>CC+</sub> and V<sub>CC-</sub> unless otherwise noted.

The inputs are protected by back-to-back diodes. Current-limiting resistors are not used in order to achieve low noise. Excessive
input current will flow if a differential input voltage in excess of approximately ± 0.7 V is applied between the inputs unless some
limiting resistance is used.

#### **DISSIPATION RATING TABLE**

PACKAGE	$T_{\mbox{\scriptsize A}} \leq 25^{\circ}\mbox{\scriptsize C}$ POWER RATING	DERATING FACTOR ABOVE T <sub>A</sub> = 25°C	T <sub>A</sub> = 85°C POWER RATING	T <sub>A</sub> = 125°C POWER RATING
JG	1050 mW	8.4 mW/°C	546 mW	210 mW
FK	1375 mW	11.0 mW/°C	715 mW	275 mW
Р	1000 mW	8.0 mW/°C	520 mW	N/A

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#### recommended operating conditions

		OP2	7A, OP3	37A	OP2	27C, OP3	37C	UNIT
		MIN	NOM	MAX	MIN	NOM	MAX	UNIT
Supply voltage, V <sub>CC+</sub>		4	15	22	4	15	22	V
Supply voltage, V <sub>CC</sub> _		-4	-15	-22	-4	-15	-22	V
Common mode input voltage V. a	$V_{CC\pm} = \pm 15 \text{ V}, T_A = 25^{\circ}\text{C}$	± 11			±11			V
Common-mode input voltage, V <sub>IC</sub>	$V_{CC\pm} = \pm 15 \text{ V}, T_A = -55^{\circ}\text{C to } 125^{\circ}\text{C}$	±10.3			±10.2			V
Operating free-air temperature, TA	_	-55		125	-55		125	°C

#### electrical characteristics at specified free-air temperature, $V_{CC\pm}$ = $\pm 15$ V (unless otherwise noted)

	DADAMETED		NIDITIONS		OP:	27A, OP3	7A	OP	27C, OP3	37C	
	PARAMETER	TEST CC	ONDITIONS	T <sub>A</sub> †	MIN	TYP	MAX	MIN	TYP	MAX	UNIT
V	Input offset voltage	$V_{O} = 0$ ,	V <sub>IC</sub> = 0	25°C		10	25		30	100	μV
VIO	input onset voltage	$R_S = 50 \Omega$ ,	See Note 3	Full range			60			300	μν
αVIO	Average temperature coefficient of input offset voltage			Full range		0.2	0.6		0.4	1.8	μV/°C
	Long-term drift of input offset voltage	See Note 4				0.2	1		0.4	2	μV/mo
IIO	Input offset current	V <sub>O</sub> = 0,	VIC = 0	25°C		7	35		12	75	nA
10	input onset current	VO = 0,	VIC = 0	Full range			50			135	11/-
I <sub>IB</sub>	Input bias current	$V_{O} = 0$ ,	VIC = 0	25°C		±10	±40		±15	±80	nA
чВ	Input bias current	VO = 0,	VIC = 0	Full range			±60			±150	11/-
Vion	Common-mode input			25°C	11 to –11			11 to –11			V
VICR	voltage range			Full range	10.3 to -10.3			10.5 to -10.5		V	
		$R_L \ge 2 k\Omega$			±12	±13.8		±11.5	±13.5		
$V_{\text{OM}}$	Peak output voltage swing	$R_L \ge 0.6 \text{ k}\Omega$			±10	±11.5		±10	±11.5		V
		$R_L \ge 2 k\Omega$		Full range	±11.5			10.5			
		$R_L \ge 2 k\Omega$ ,	$V_0 = \pm 10 \text{ V}$		1000	1800		700	1500		
	Large-signal differential	$R_L \ge 1 \ k\Omega$ ,	$V_0 = \pm 10 \text{ V}$		800	1500			1500		
AVD	voltage amplification	$R_L \ge 0.6 \text{ k}\Omega$ $V_{CC\pm} = \pm 4$	$V_{O} = \pm 1 \text{ V},$		250	700		200	500		V/mV
		$R_L \ge 2 k\Omega$ ,	$V_0 = \pm 10 \text{ V}$	Full range	600			300			
ri(CM)	Common-mode input resistance					3			2		GΩ
r <sub>O</sub>	Output resistance	$V_{O} = 0$ ,	IO = 0	25°C		70			70		Ω
CMRR	Common-mode rejection	V <sub>IC</sub> = ±11 V	1	25°C	114	126		100	120		dB
OWINK	ratio	V <sub>IC</sub> = ±10 \	1	Full range	110			94			ub
ksvr	Supply voltage rejection	$V_{CC\pm} = \pm 4$		25°C	100	120		94	118		dB
2VK	ratio	$V_{CC\pm} = \pm 4$	.5 V to ±18 V	Full range	96			86			40

<sup>†</sup> Full range is – 55°C to 125°C.

NOTES: 3. Input offset voltage measurements are performed by automatic test equipment approximately 0.5 seconds after applying power.

<sup>4.</sup> Long-term drift of input offset voltage refers to the average trend line of offset voltage versus time over extended periods after the first 30 days of operation. Excluding the initial hour of operation, changes in  $V_{IO}$  during the first 30 days are typically 2.5  $\mu$ V (see Figure 3).



#### LOW-NOISE HIGH-SPEED PRECISION OPERATIONAL AMPLIFIERS

recommended operating conditions

			MIN	NOM	MAX	UNIT
Supply voltage, V <sub>CC+</sub>			4	15	22	V
Supply voltage, V <sub>CC</sub> _			-4	-15	-22	V
Common mode input voltage V. a	$V_{CC\pm} = \pm 15 \text{ V},$	T <sub>A</sub> = 25°C	±11			V
Common-mode input voltage, V <sub>IC</sub>	$V_{CC\pm} = \pm 15 \text{ V},$	$T_A = -55^{\circ}C \text{ to } 125^{\circ}C$	±10.5			V
Operating free-air temperature, TA	•		-25		85	°C

#### electrical characteristics at specified free-air temperature, $V_{CC\pm}$ = $\pm 15$ V (unless otherwise noted)

PARAMETER		TEST O	ONDITIONS		OP	27E, OP3	7E	OP	27G, OP3	37G	UNIT
	PARAMETER	IESI C	ONDITIONS	T <sub>A</sub> †	MIN	TYP	MAX	MIN	TYP	MAX	UNII
VIO	Input offset voltage	$V_0 = 0,$		25°C		10	25		30	100	μV
VIO	input onset voltage	$R_S = 50 \Omega$ ,	See Note 3	Full range			60			220	μν
α۷ιΟ	Average temperature coefficient of input offset voltage			Full range		0.2	0.6		0.4	1.8	μV/°C
	Long-term drift of input offset voltage	See Note 4				0.2	1		0.4	2	μV/mo
lio	Input offset current	V <sub>O</sub> = 0,	VIC = 0	25°C		7	35		12	75	nA
110	input onset current	VO = 0,	VIC = 0	Full range			50			135	ПА
I <sub>IB</sub>	Input bias current	$V_{O} = 0,$	V10 = 0	25°C		±10	±40		±15	±80	nA
I IB	mpat blad darrent	VO = 0,	VIC = 0	Full range		-	±60			±150	117 (
VICR	Common-mode input			25°C	11 to –11			11 to –11			V
TICK	voltage range			Full range	10.3 to -10.3			10.5 to –10.5		v	,
		$R_L \ge 2 k\Omega$			±12	±13.8		±11.5	±13.5		
Vом	Peak output voltage swing	$R_L \ge 0.6 k\Omega$	!		±10	±11.5		±10	±11.5		V
		$R_L \ge 2 k\Omega$		Full range	±11.5	-		10.5			
			$V_0 = \pm 10 \text{ V}$	]	1000	1800		700	1500		
	Large-signal differential		$V_0 = \pm 10 \text{ V}$		800	1500			1500		
AVD	voltage amplification	R <sub>L</sub> $\geq$ 0.6 kΩ V <sub>CC±</sub> = ± 4	$V_0 = \pm 1 \text{ V},$		250	700		200	500		V/mV
		$R_L \ge 2 k\Omega$ ,	$V_0 = \pm 10 \text{ V}$	Full range	600			450			
ri(CM)	Common-mode input resistance					3			2		GΩ
r <sub>O</sub>	Output resistance	$V_{O} = 0$ ,	IO = 0	25°C		70			70		Ω
CMRR	Common-mode rejection	V <sub>IC</sub> = ±11 V	1	25°C	114	126		100	120		dB
CIVILLY	ratio	V <sub>IC</sub> = ±10 \	/	Full range	110			96			ub_
ksvr	Supply voltage rejection	$V_{CC\pm} = \pm 4$		25°C	100	120		94	118		dB
"OVK	ratio	$V_{CC\pm} = \pm 4$	.5 V to ±18 V	Full range	96			90			<u> </u>

<sup>†</sup>Full range is – 25°C to 85°C.

NOTES: 3. Input offset voltage measurements are performed by automatic test equipment approximately 0.5 seconds after applying power.

<sup>4.</sup> Long-term drift of input offset voltage refers to the average trend line of offset voltage versus time over extended periods after the first 30 days of operation. Excluding the initial hour of operation, changes in V<sub>IO</sub> during the first 30 days are typically 2.5 μV (see Figure 3).



#### OP27 operating characteristics over operating free-air temperature range, $V_{CC\pm}$ = $\pm 15~V$

	PARAMETER	TEST CON	OITIONS	OP2	7A, OP2	27E	OP2	UNIT		
	PARAIVIETER	TEST CON	TEST CONDITIONS		TYP	MAX	MIN	TYP	MAX	UNIT
SR	Slew rate	$A_{VD} \ge 1$ ,	$R_L \ge 2 \ k\Omega$	1.7	2.8		1.7	2.8		V/μs
V <sub>N(PP)</sub>	Peak-to-peak equivalent input noise voltage	f = 0.1 Hz to 10 Hz, See Figure 34	$R_S = 20 \Omega$ ,		0.08	0.18		0.09	0.25	μV
		f = 10 Hz,	R <sub>S</sub> = 20 Ω		3.5	5.5		3.8	8	
٧n	Equivalent input noise voltage	f = 30 Hz,	$R_S = 20 \Omega$		3.1	4.5		3.3	5.6	nV/√ <del>Hz</del>
		f = 1 kHz,	$R_S = 20 \Omega$		3	3.8		3.2	4.5	
		f = 10 Hz,	See Figure 35		1.5	4		1.5		
In	Equivalent input noise current	f = 30 Hz,	See Figure 35		1	2.3		1		pA/√ <del>Hz</del>
		f = 1 kHz,	See Figure 35		0.4	0.6		0.4	0.6	
	Gain-bandwidth product	f = 100 kHz		5	8	·	5	8		MHz

#### OP37 operating characteristics over operating free-air temperature range, $V_{CC\pm}$ = $\pm 15~V$

PARAMETER		TEST CON	TEST CONDITIONS		OP37A, OP37E			OP37C, OP37G		
	PARAIVIETER	I EST CON	DITIONS	MIN	TYP	MAX	MIN	TYP	MAX	UNIT
SR	Slew rate	$A_{VD} \ge 5$ ,	$R_L \ge 2 k\Omega$	11	17		11	17		V/μs
V <sub>N(PP)</sub>	Peak-to-peak equivalent input noise voltage	f = 0.1 Hz to 10 Hz, See Figure 34	$R_S = 20 \Omega$ ,		0.08	0.18		0.09	0.25	μV
		f = 10 Hz,	R <sub>S</sub> = 20 Ω		3.5	5.5		3.8	8	
٧n	Equivalent input noise voltage	f = 30 Hz,	R <sub>S</sub> = 20 Ω		3.1	4.5		3.3	5.6	nV/√Hz
	vollage	f = 1 kHz,	R <sub>S</sub> = 20 Ω		3	3.8		3.2	4.5	1
		f = 10 Hz,	See Figure 35		1.5	4		1.5		
In	Equivalent input noise current	f = 30 Hz,	See Figure 35		1	2.3		1		pA/√Hz
		f = 1 kHz,	See Figure 35		0.4	0.6		0.4	0.6	1
	Coin bondwidth product	f = 10 kHz		45	63		45	63		MHz
	Gain-bandwidth product	$A_V \ge 5$ ,	f = 1 MHz		40			40		1 IVIHZ

#### **TYPICAL CHARACTERISTICS**

#### **Table of Graphs**

			FIGURE
VIO	Input offset voltage	vs Temperature	1
ΔVΙΟ	Change in input offset voltage	vs Time after power on vs Time (long-term drift)	2 3
I <sub>IO</sub>	Input offset current	vs Temperature	4
I <sub>IB</sub>	Input bias current	vs Temperature	5
VICR	Common-mode input voltage range	vs Supply voltage	6
Vом	Maximum peak output voltage	vs Load resistance	7
V <sub>O(PP)</sub>	Maximum peak-to-peak output voltage	vs Frequency	8, 9
AVD	Differential voltage amplification	vs Supply voltage vs Load resistance vs Frequency	10 11 12, 13, 14
CMRR	Common-mode rejection ratio	vs Frequency	15
ksvr	Supply voltage rejection ratio	vs Frequency	16
SR	Slew rate	vs Temperature vs Supply voltage vs Load resistance	17 18 19
φm	Phase margin	vs Temperature	20, 21
ф	Phase shift	vs Frequency	12, 13
V <sub>n</sub>	Equivalent input noise voltage	vs Bandwidth vs Source resistance vs Supply voltage vs Temperature vs Frequency	22 23 24 25 26
In	Equivalent input noise current	vs Frequency	27
	Gain-bandwidth product	vs Temperature	20, 21
los	Short-circuit output current	vs Time	28
Icc	Supply current	vs Supply voltage	29
	Pulse response	Small signal Large signal	30, 32 31, 33

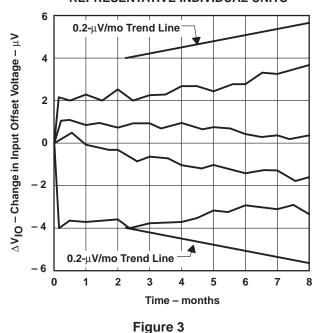
Figure 1

#### TYPICAL CHARACTERISTICS<sup>†</sup>

#### **WARM-UP CHANGE IN** INPUT OFFSET VOLTAGE OF REPRESENTATIVE INDIVIDUAL UNITS **INPUT OFFSET VOLTAGE** FREE-AIR TEMPERATURE **ELAPSED TIME** 100 $V_{CC\pm} = \pm 15 V$ $V_{CC\pm} = \pm 15 V$ 80 T<sub>A</sub> = 25°C $\Delta V_{\mbox{\scriptsize IO}} - \mbox{\scriptsize Change}$ in Input Offset Voltage – $\mu \mbox{\scriptsize V}$ OP27C/37C 60 10 $V_{IO}$ – Input Offset Voltage – $\mu V$ OP27CP/GP OP27A/37A 40 OP27A/37A OP37CP/GP 20 0 OP27E/37E - 20 5 - 40 OP27G/37G OP27AP/EP OP27C/37C OP37AP/EP - 60 - 80 - 100 - 50 - 25 50 75 100 125 5 T<sub>A</sub> - Free-Air Temperature - °C Time After Power On - minutes

#### LONG-TERM DRIFT OF INPUT OFFSET VOLTAGE OF REPRESENTATIVE INDIVIDUAL UNITS

Figure 2





-75 -50 -25

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**INPUT BIAS CURRENT** 

FREE-AIR TEMPERATURE

#### TYPICAL CHARACTERISTICS<sup>†</sup>

 $\pm\,$  50

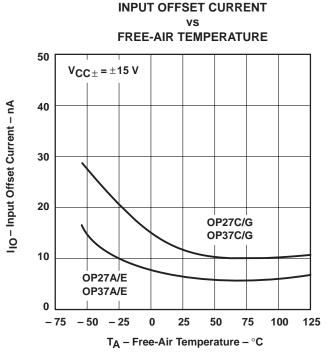
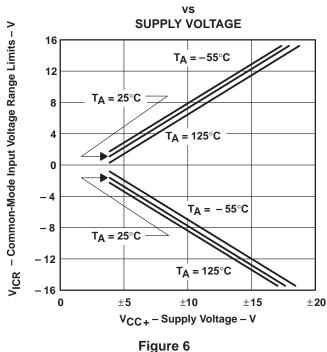


Figure 4

Figure 5

0





#### MAXIMUM PEAK OUTPUT VOLTAGE

25

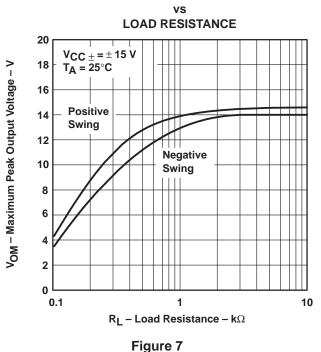
T<sub>A</sub> - Free-Air Temperature - °C

50

75

100

125





#### TYPICAL CHARACTERISTICS

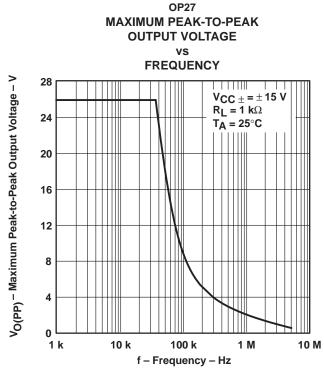


Figure 8

#### OP27A, OP27E, OP37A, OP37E LARGE-SIGNAL DIFFERENTIAL VOLTAGE AMPLIFICATION VS TOTAL SUPPLY VOLTAGE

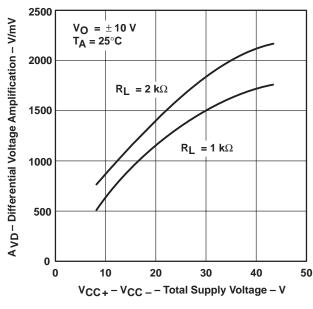


Figure 10

### OP37 MAXIMUM PEAK-TO-PEAK OUTPUT VOLTAGE vs FREQUENCY

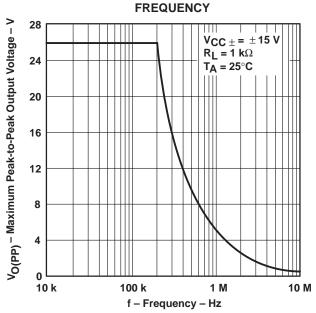


Figure 9

#### OP27A, OP27E, OP37A, OP37E LARGE-SIGNAL DIFFERENTIAL VOLTAGE AMPLIFICATION VS

LOAD RESISTANCE

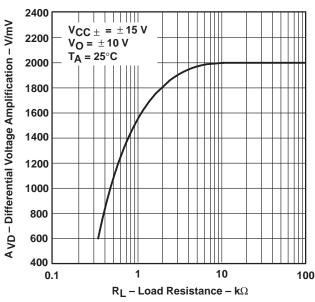
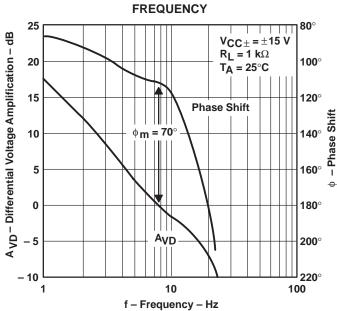


Figure 11



#### TYPICAL CHARACTERISTICS

### OP27 LARGE-SIGNAL DIFFERENTIAL VOLTAGE AMPLIFICATION AND PHASE SHIFT



OP37 LARGE-SIGNAL DIFFERENTIAL VOLTAGE AMPLIFICATION AND PHASE SHIFT

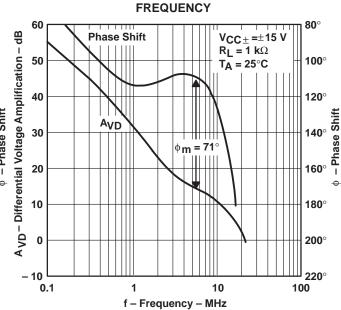


Figure 12

OP27A, OP27E, OP37A, OP37E LARGE-SIGNAL DIFFERENTIAL VOLTAGE AMPLIFICATION

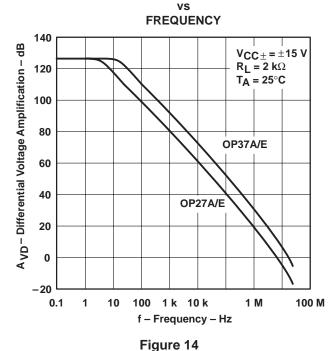


Figure 13

## OP27A, OP27E, OP37A, OP37E COMMON-MODE REJECTION RATIO VS FREQUENCY V<sub>CC±</sub> = ±15 V<sub>IC</sub> = ±10 V

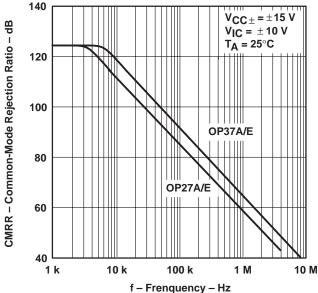
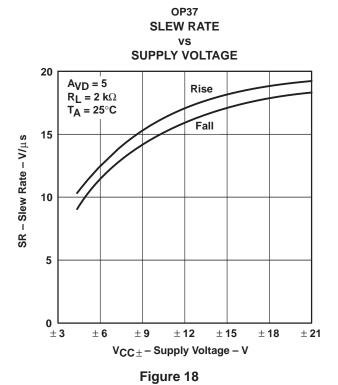


Figure 15

#### TYPICAL CHARACTERISTICS<sup>†</sup>

#### SUPPLY VOLTAGE REJECTION RATIO **FREQUENCY** 160 $V_{CC\pm} = \pm 4 \text{ V to } \pm 18 \text{ V}$ kSVR-Supply Voltage Rejection Ratio-dB T<sub>A</sub> = 25°C 140 120 100 Negative Supply 80 60 40 **Positive** Supply 20 0 10 100 1k 10k 100k 1M 10M 100M f - Frequency - Hz

Figure 16



SLEW RATE vs FREE-AIR TEMPERATURE

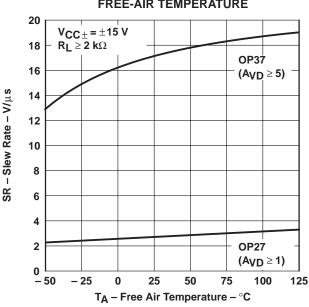
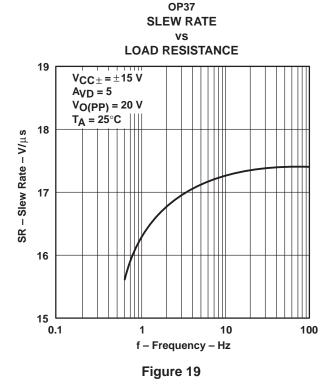


Figure 17

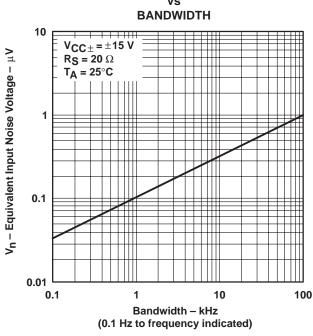




#### TYPICAL CHARACTERISTICS<sup>†</sup>

#### **OP27 OP37 PHASE MARGIN AND PHASE MARGIN AND GAIN-BANDWIDTH PRODUCT GAIN-BANDWIDTH PRODUCT** FREE-AIR TEMPERATURE FREE-AIR TEMPERATURE 809 85° 11 $V_{CC\pm} = \pm 15 V$ $V_{CC\pm} = \pm 15 \text{ V}$ 75 80 10.6 85 φm 10.2 보 70° 80 75° Gain-Bandwidth Product – MHz φm Gain-Bandwidth Product - M **70**° 65° 9.8 om-Phase Margin om-Phase Margin 60° 65° 9.4 GBW (f = 10 kHz) 60° 9 55° 50° 55° 8.6 50° 45 8.2 GBW (f = 100 kHz) 50 45 40° 40 35° 45 7.4 30° 40 359 - 75 - 50 - 25 25 50 75 100 - 50 - 25 50 75 100 125 125 T<sub>A</sub> – Free-Air Temperature – °C T<sub>A</sub> - Free-Air Temperature - °C Figure 20 Figure 21

#### **EQUIVALENT INPUT NOISE VOLTAGE** vs



#### TOTAL EQUIVALENT INPUT NOISE VOLTAGE

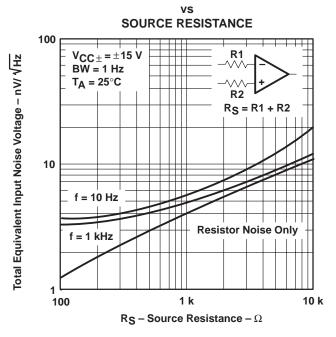


Figure 22 Figure 23

† Data for temperatures below - 25°C and above 85°C are applicable to the OP27A, OP27C, OP37A, and OP37C only.

RUMENTS POST OFFICE BOX 655303 ● DALLAS, TEXAS 75265 POST OFFICE BOX 1443 ● HOUSTON, TEXAS 77251-1443

#### TYPICAL CHARACTERISTICS<sup>†</sup>

#### OP27A, OP27E, OP37A, OP37E **EQUIVALENT INPUT NOISE VOLTAGE**

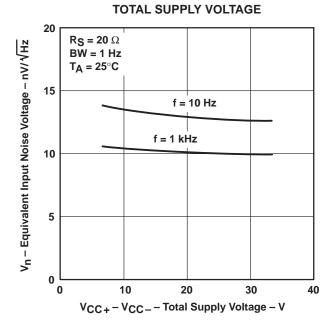


Figure 24

#### OP27A, OP27E, OP37A, OP37E **EQUIVALENT INPUT NOISE VOLTAGE** FREE-AIR TEMPERATURE

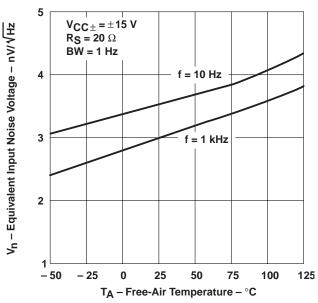


Figure 25

#### OP27A, OP27E, OP37A, OP37E **EQUIVALENT INPUT NOISE VOLTAGE**

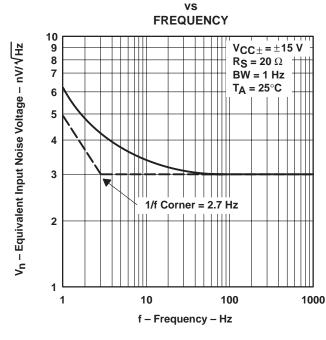


Figure 26

#### **EQUIVALENT INPUT NOISE CURRENT** vs

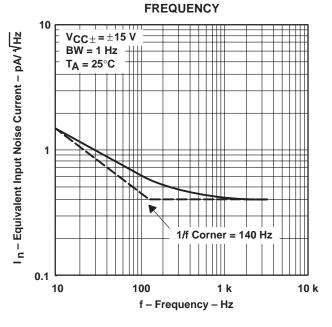
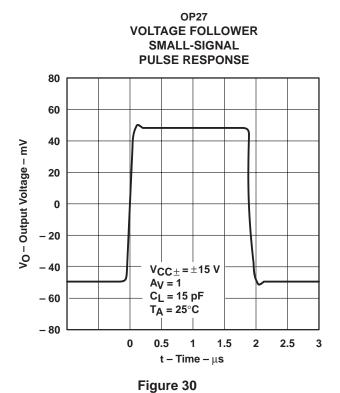


Figure 27

#### TYPICAL CHARACTERISTICS<sup>†</sup>

#### SHORT-CIRCUIT OUTPUT CURRENT **ELAPSED TIME** 60 $V_{CC\pm} = \pm 15 V$ T<sub>A</sub> = 25°C IOS - Short-Circuit Output Current - mA 50 los-40 30 los+ 20 10 2 3 0 4 5 t - Time - minutes

Figure 28



SUPPLY CURRENT

VS

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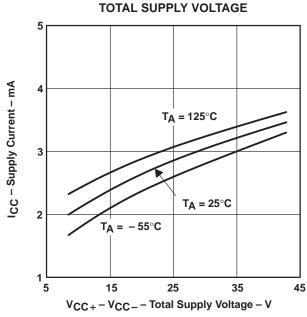
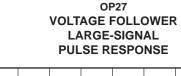


Figure 29



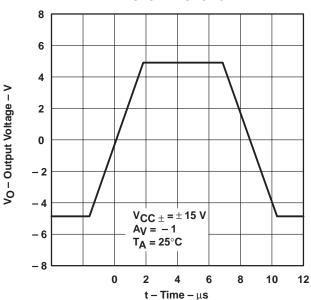
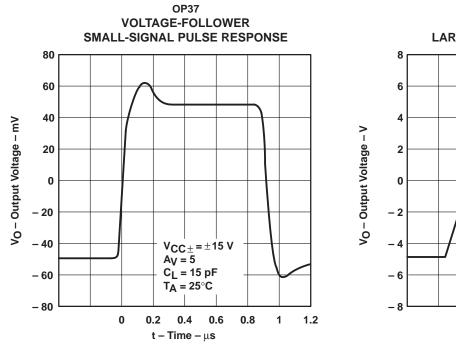
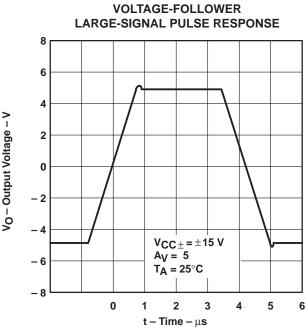


Figure 31



#### TYPICAL CHARACTERISTICS





**OP37** 

Figure 32 Figure 33

#### **APPLICATION INFORMATION**

#### general

The OP27 and OP37 series devices can be inserted directly onto OP07, OP05,  $\mu$ A725, and SE5534 sockets with or without removing external compensation or nulling components. In addition, the OP27 and OP37 can be fitted to  $\mu$ A741 sockets by removing or modifying external nulling components.

#### noise testing

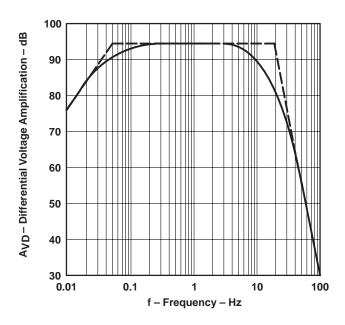
Figure 34 shows a test circuit for 0.1-Hz to 10-Hz peak-to-peak noise measurement of the OP27 and OP37. The frequency response of this noise tester indicates that the 0.1-Hz corner is defined by only one zero. Because the time limit acts as an additional zero to eliminate noise contributions from the frequency band below 0.1 Hz, the test time to measure 0.1-Hz to 10-Hz noise should not exceed 10 seconds.

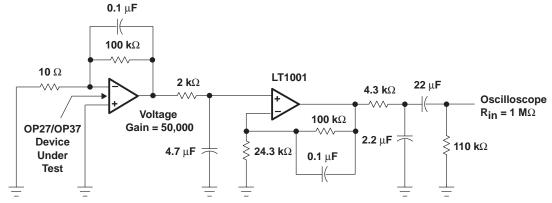
Measuring the typical 80-nV peak-to-peak noise performance of the OP27 and OP37 requires the following special test precautions:

- 1. The device should be warmed up for at least five minutes. As the operational amplifier warms up, the offset voltage typically changes  $4\,\mu\text{V}$  due to the chip temperature increasing from 10°C to 20°C starting from the moment the power supplies are turned on. In the 10-s measurement interval, these temperature-induced effects can easily exceed tens of nanovolts.
- 2. For similar reasons, the device should be well shielded from air currents to eliminate the possibility of thermoelectric effects in excess of a few nanovolts, which would invalidate the measurements.
- 3. Sudden motion in the vicinity of the device should be avoided, as it produces a feedthrough effect that increases observed noise.



#### **APPLICATION INFORMATION**





NOTE: All capacitor values are for nonpolarized capacitors only.

Figure 34. 0.1-Hz to 10-Hz Peak-to-Peak Noise Test Circuit and Frequency Response

#### **APPLICATION INFORMATION**

When measuring noise on a large number of units, a noise-voltage density test is recommended. A 10-Hz noise-voltage density measurement correlates well with a 0.1-Hz to 10-Hz peak-to-peak noise reading since both results are determined by the white noise and the location of the 1/f corner frequency.

Figure 35 shows a circuit measuring current noise and the formula for calculating current noise.

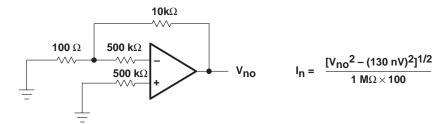


Figure 35. Current Noise Test Circuit and Formula

#### offset voltage adjustment

The input offset voltage and temperature coefficient of the OP27 and OP37 are permanently trimmed to a low level at wafer testing. However, if further adjustment of  $V_{IO}$  is necessary, using a 10-k $\Omega$  nulling potentiometer as shown in Figure 36 does not degrade the temperature coefficient  $\alpha_{VIO}$ . Trimming to a value other than zero creates an  $\alpha_{VIO}$  of  $V_{IO}/300~\mu\text{V/}^{\circ}\text{C}$ . For example, if  $V_{IO}$  is adjusted to 300  $\mu$ V, the change in  $\alpha_{VIO}$  is 1  $\mu$ V/°C.

The adjustment range with a 10-k $\Omega$  potentiometer is approximately  $\pm 2.5$  mV. If a smaller adjustment range is needed, the sensitivity and resolution of the nulling can be improved by using a smaller potentiometer in conjunction with fixed resistors. The example in Figure 37 has an approximate null range of  $\pm 200~\mu$ V.

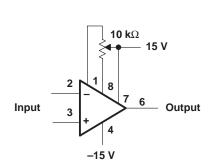


Figure 36. Standard Input Offset Voltage Adjustment

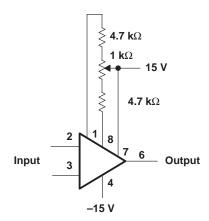


Figure 37. Input Offset Voltage Adjustment With Improved Sensitivity

#### offset voltage and drift

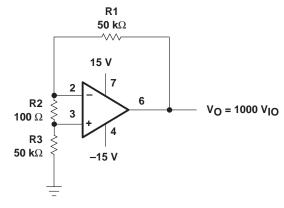
Unless proper care is exercised, thermoelectric effects caused by temperature gradients across dissimilar metals at the contacts to the input terminals can exceed the inherent temperature coefficient  ${}^{\infty}V_{IO}$  of the amplifier. Air currents should be minimized, package leads should be short, and the two input leads should be close together and at the same temperature.

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#### **APPLICATION INFORMATION**

#### offset voltage and drift (continued)

The circuit shown in Figure 38 measures offset voltage. This circuit can also be used as the burn-in configuration for the OP27 and OP37 with the supply voltage increased to 20 V, R1 = R3 = 10 k $\Omega$ , R2 = 200  $\Omega$ , and A<sub>VD</sub> = 100.



NOTE A: Resistors must have low thermoelectric potential.

Figure 38. Test Circuit for Offset Voltage and Offset Voltage Temperature Coefficient

#### unity gain buffer applications

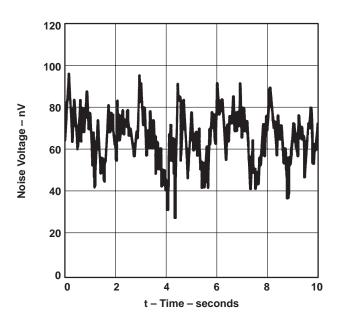
The resulting output waveform, when  $R_f \le 100 \Omega$  and the input is driven with a fast large-signal pulse (> 1 V), is shown in the pulsed-operation diagram in Figure 39.



Figure 39. Pulsed Operation

During the initial (fast-feedthrough-like) portion of the output waveform, the input protection diodes effectively short the output to the input, and a current, limited only by the output short-circuit protection, is drawn by the signal generator. When  $R_f \geq 500~\Omega$ , the output is capable of handling the current requirements (load current  $\leq 20~\text{mA}$  at 10 V), the amplifier stays in its active mode, and a smooth transition occurs. When  $R_f > 2~\text{k}\Omega$ , a pole is created with  $R_f$  and the amplifier's input capacitance, creating additional phase shift and reducing the phase margin. A small capacitor (20 pF to 50 pF) in parallel with  $R_f$  eliminates this problem.

#### **APPLICATION INFORMATION**



#### Type S Thermocouples 5.4 μV/°C at 0°C #1 **Cold-Junction** Circuitry To Gate Drive $A_{VD} = 10,000$ #2 Output **OP27** Typical 100 $k\Omega$ $0.05 \mu F >$ Multiplexing **FET Switches** #24 **High-Quality** 10 $\Omega$ Single-Point Ground

NOTE A: If 24 channels are multiplexed per second and the output is required to settle to 0.1 % accuracy, the amplifier's bandwidth cannot be limited to less than 30 Hz. The peak-to-peak noise contribution of the OP27 will still be only 0.11  $\mu$ V, which is equivalent to an error of only 0.02°C.

Figure 40. Low-Noise, Multiplexed Thermocouple Amplifier and 0.1-Hz To 10-Hz Peak-to-Peak Noise Voltage



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